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Variations in hydrogen sulfide concentrations in a wastewater pumping station with an odor control system

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Outline

1. Introduction
2. Plant Description
3. Monitoring Program
4. Results and Discussion
5. Conclusions

1. Introduction

Odorous Compounds Associated with Municipal Wastewater

Odorous Compounds	Example Gases
Inorganic Gases	Ammonia, Hydrogen Sulfide
Mercaptans	(Allyl, Amyl, Benzyl, Methyl, Ethyl) Mercaptan
Other Organic Sulfides	Dimethyl Sulfide, Thiocresol, Thiophenol
Diamines	Cadaverines (1, 5 pentanediamine)
Other Organic N	Idole, Pyridine, Skatole
Volatile Fatty Acids (VFA)	(Acetic, Propionic, Butyric) Acids
Amines	(Dibutyl, Di-isopropyl, Dimethyl, Triethyl) Amines

Introduction

Odorous Sulfur Compounds in Wastewater

Odorous Sulfur Compounds in Wastewater

Substance	Odor Threshold (ppm)	Molecular Weight
Allyl Mercaptan	0.00005	74.15
Dimethyl Sulfide	0.0001	62.13
Ethyl Mercaptan	0.000019	62.1
Hydrogen Sulfide	**0.00047**	**34.1**
Methyl Mercaptan	0.0011	48.1
Thiocresol	0.000062	124.21
Thiophenol	0.000062	110.18

Introduction

Chemistry of Hydrogen Sulfide Formation in Wastewater

$$SO_4^{2-} + \text{Organic Matter} \rightarrow S^{2-} + H_2O + CO_2 \textit{ (due to anaerobic reaction)}$$

$$S^{2-} + 2H^{+} \rightarrow H_2S$$

Introduction

Health Impacts Associated With Hydrogen Sulfide

Exposure Routes	Health Impact						
	Death	Systemic Effect	Immunological Effect	Neurological Effect	Reproductive Effect	Development Effect	Cancer
Inhalation	Yes	Yes	None	Yes	Limited Data	None	None
Oral	None	None	None	None	None	None	None
Dermal	None	None	None	None	None	None	None

Odor Control Technology

Odor Control Technology	Types of odor treated	H_2S Concentration ppm	Air flow range m^3/h	Efficiency %
Adsorption (Activated Carbon)	VOCs, H2S, broad range of compounds	Peak Less than 250 Average Less than 50	500 - 15,000	Greater than 99%
Bioscrubber	VOCs, NH3, H2S	Less than 1000	500 - 50,000*	Greater than 99%
Chemical Scrubber	Soluble odorous compounds including NH3	Up-to 2000	Greater than 2000 500 - 50,000*	99.9%

2. Plant Description

Plant Description

- Plant was commissioned in 2007 and designated as

Pumping station A7, occupying an area it occupies an area of 42,500 m^2 (450,000 ft^2).

- it is designed to handle 778,000 cubic meter

of sewage per day (200 MGD) a population of 1.4 million.

- raw sewage enters through the 20-ton inlet gate

that controls the flow, then passes through screens that remove solids and goes into a grit removal system (head works).

- after that the sewage is stored in a reservoir which serves as a

buffer tank before the main pumps. Then it is pumped on to WWTP via eight main pumps.

- an odor control system is installed at the headworks comprising wet scrubbers with addition of NaOCL / NaOH, then carbon filters.

Pumping Station A 7

The Station includes:

- main pumps
- primary cleaning equipment
- flow control equipment
- odor control system,
- lifting equipment
- building services
- complete SCADA control system.

Main Pumps

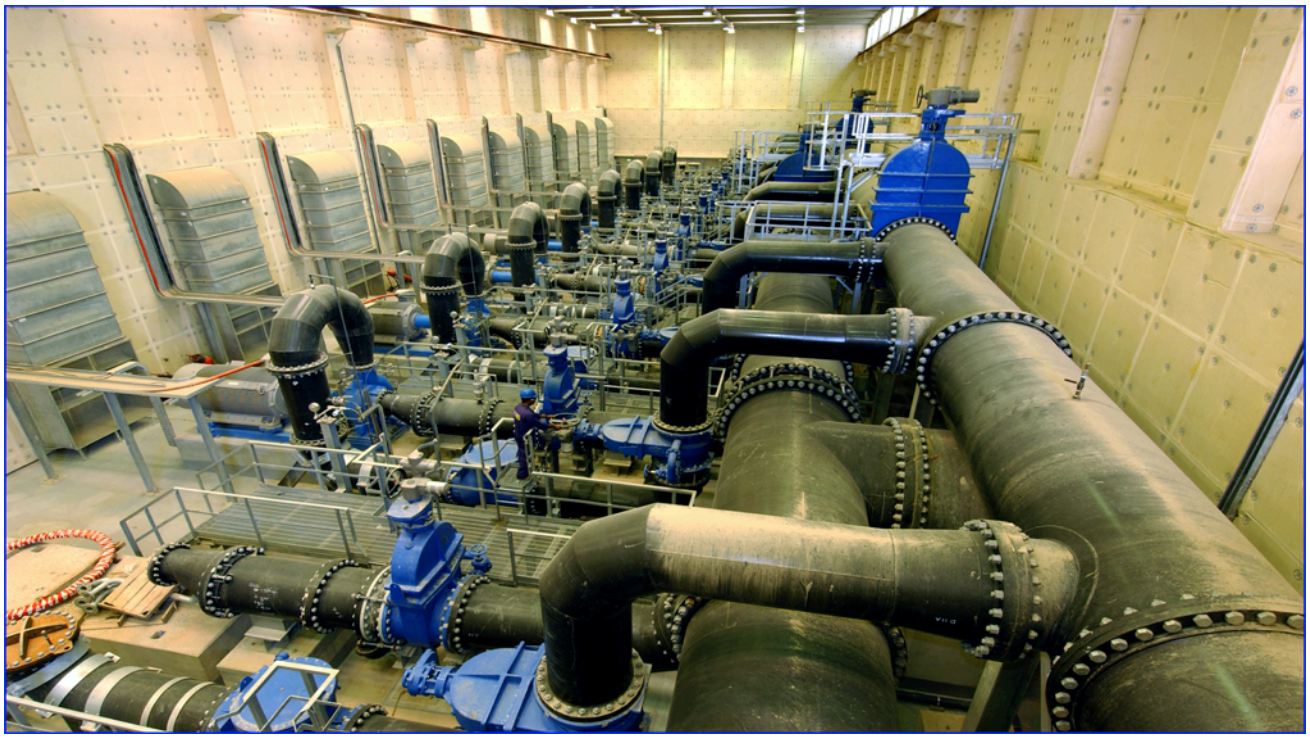


Fig. 1. Main pumping station

Odor Control System

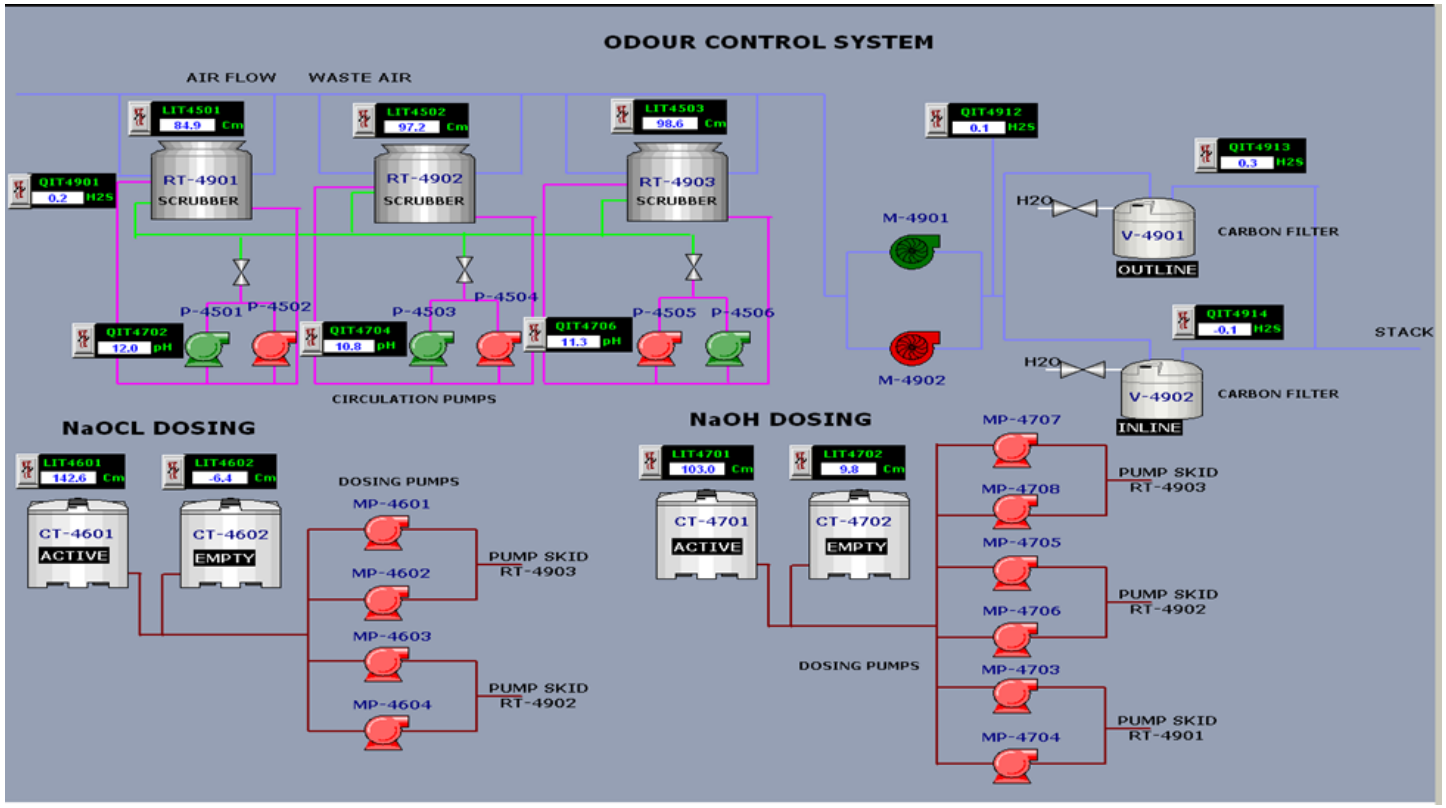


Fig. 2. Odor control system

3. Monitoring Program

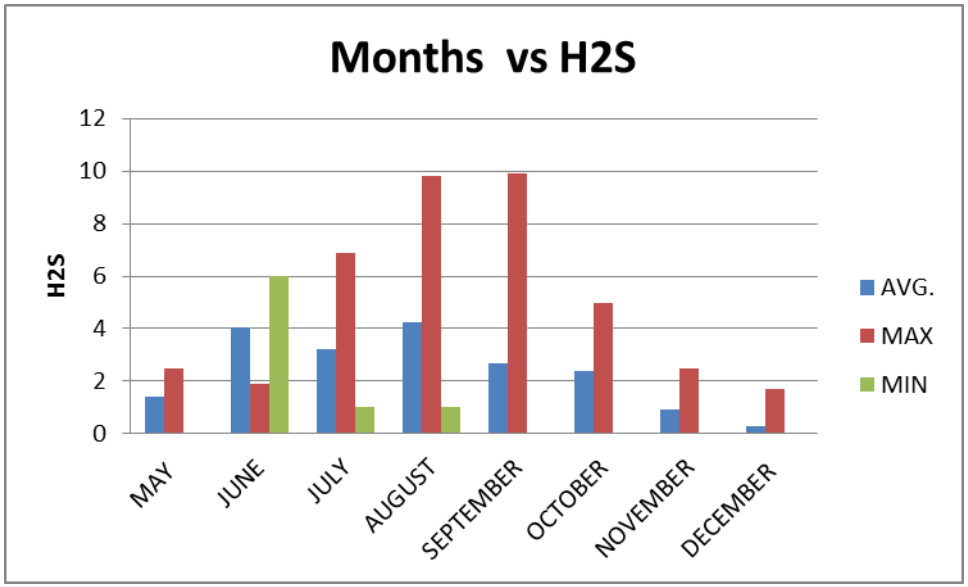
The program lasted for 8 months and included:

- Hourly variations of H2S.
- Daily variations of flow, temperature, BOD, pH, DO, sulfates and sulfides.
- H2S emissions and temperatures from the headworks were continuously monitored at each location by OdaLog units.
- Continuous flow data was obtained from the flow meters installed in the plant.

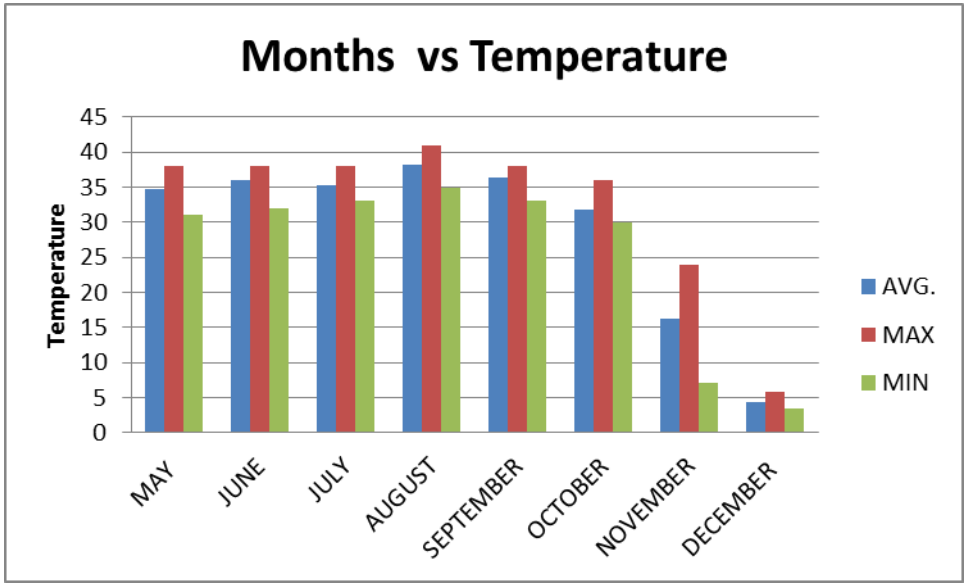
Odalog Units for H2S Monitoring

4. Results and Discussion

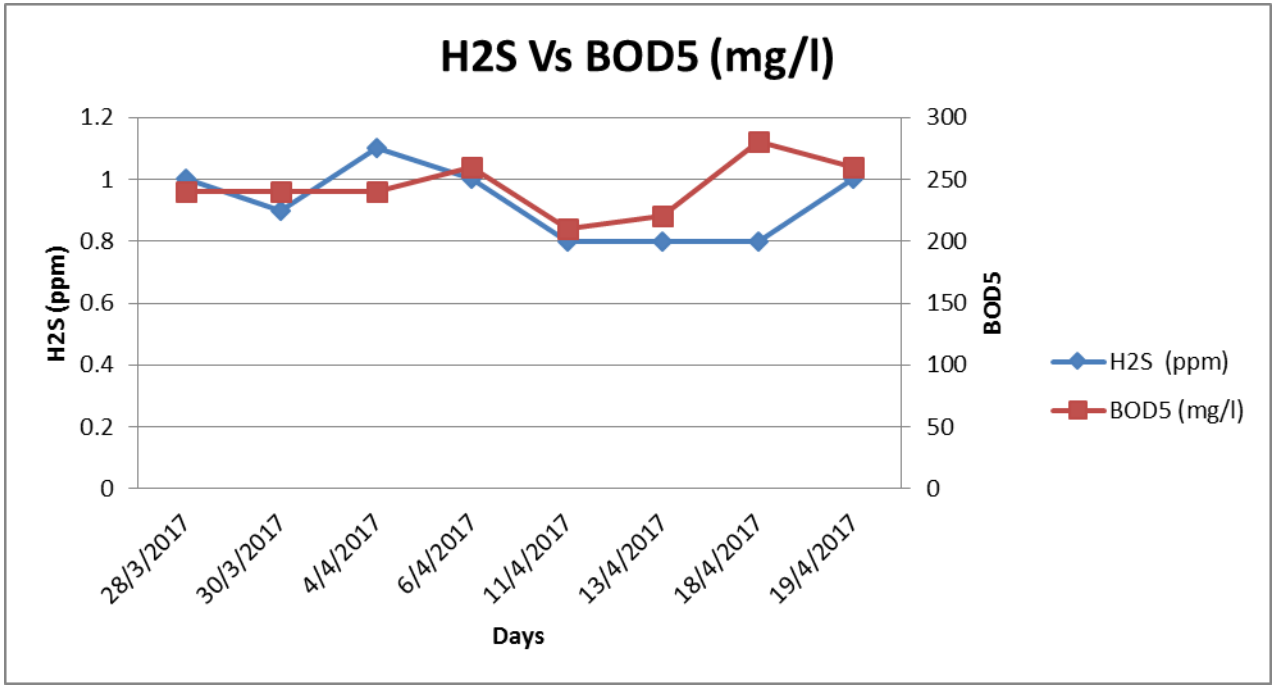
Monthly Variations in H2S



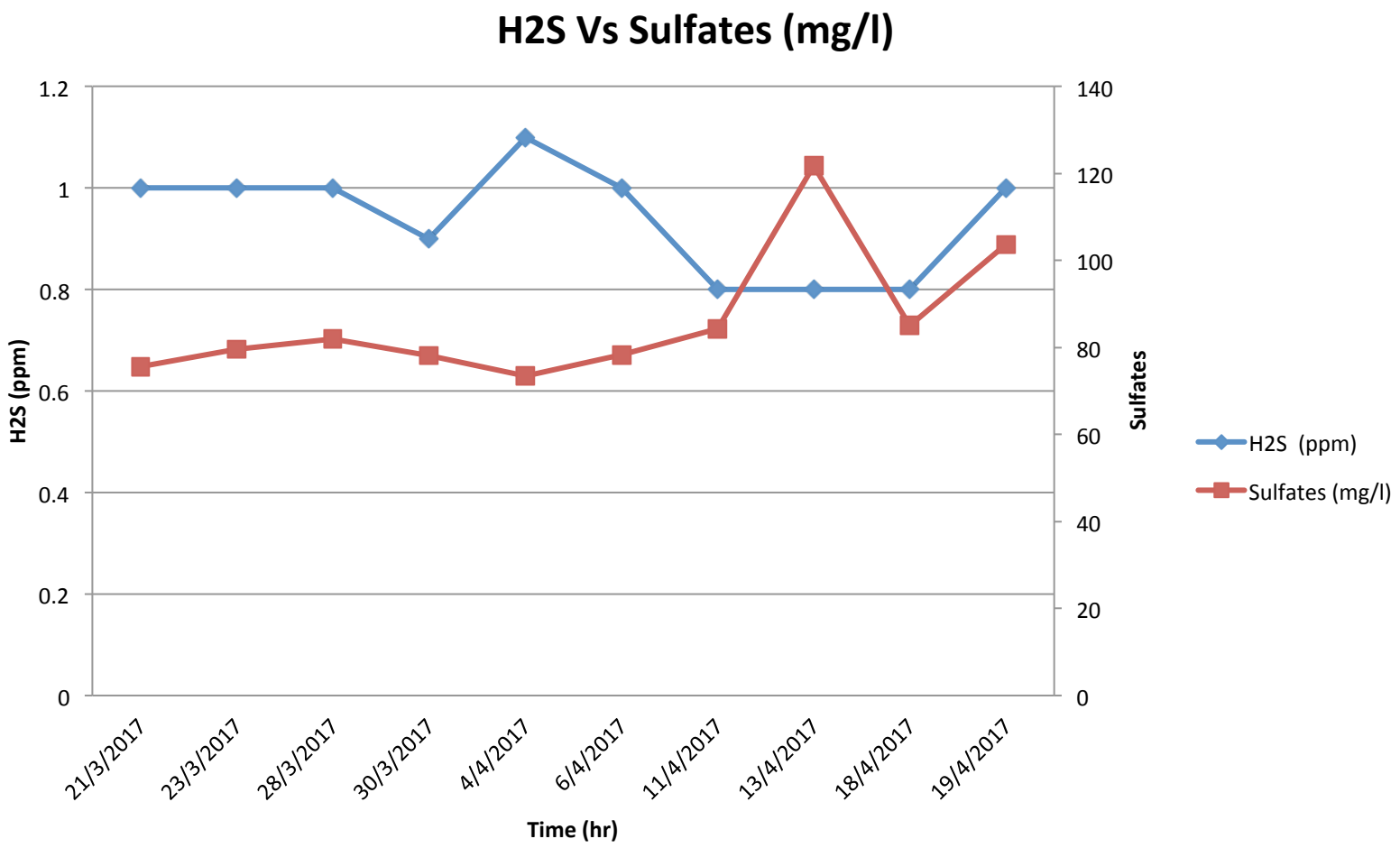
Monthly Variations in WW Temperature



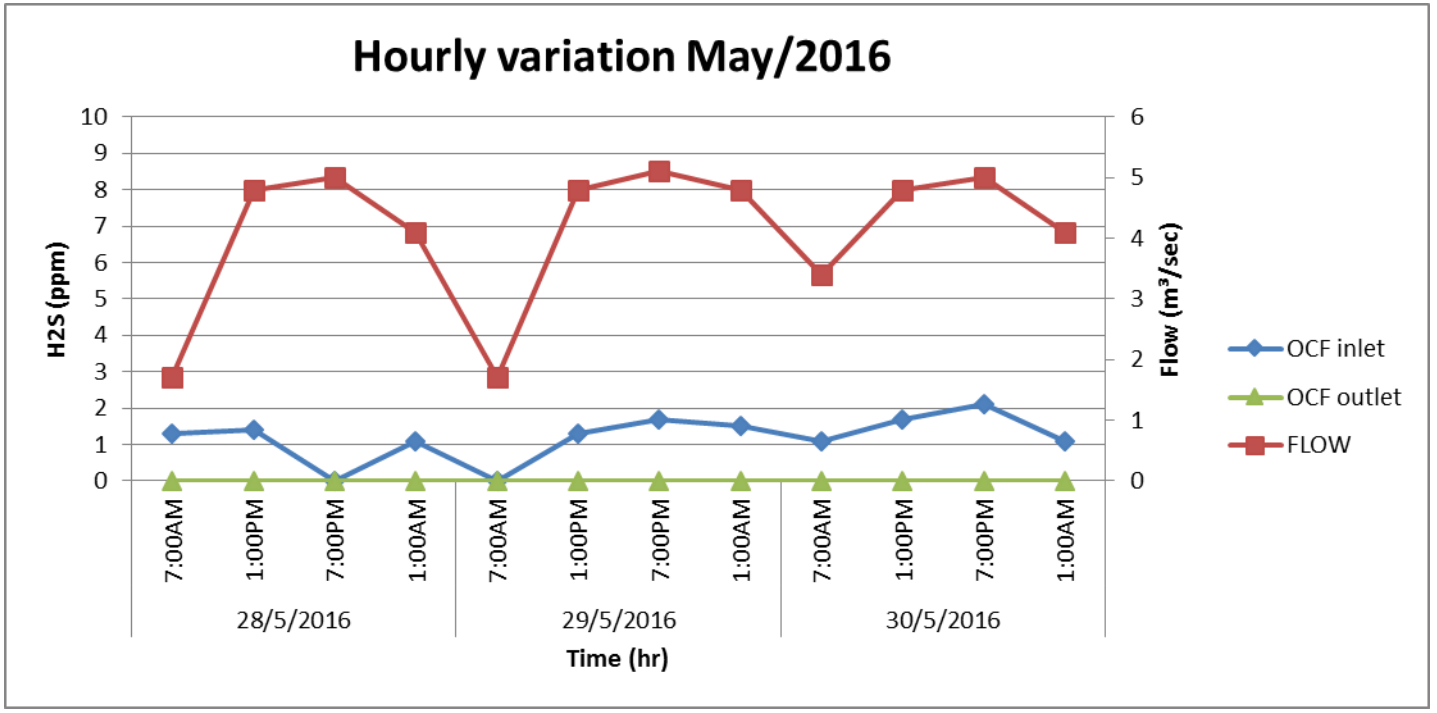
Daily Variations in H2S with BOD



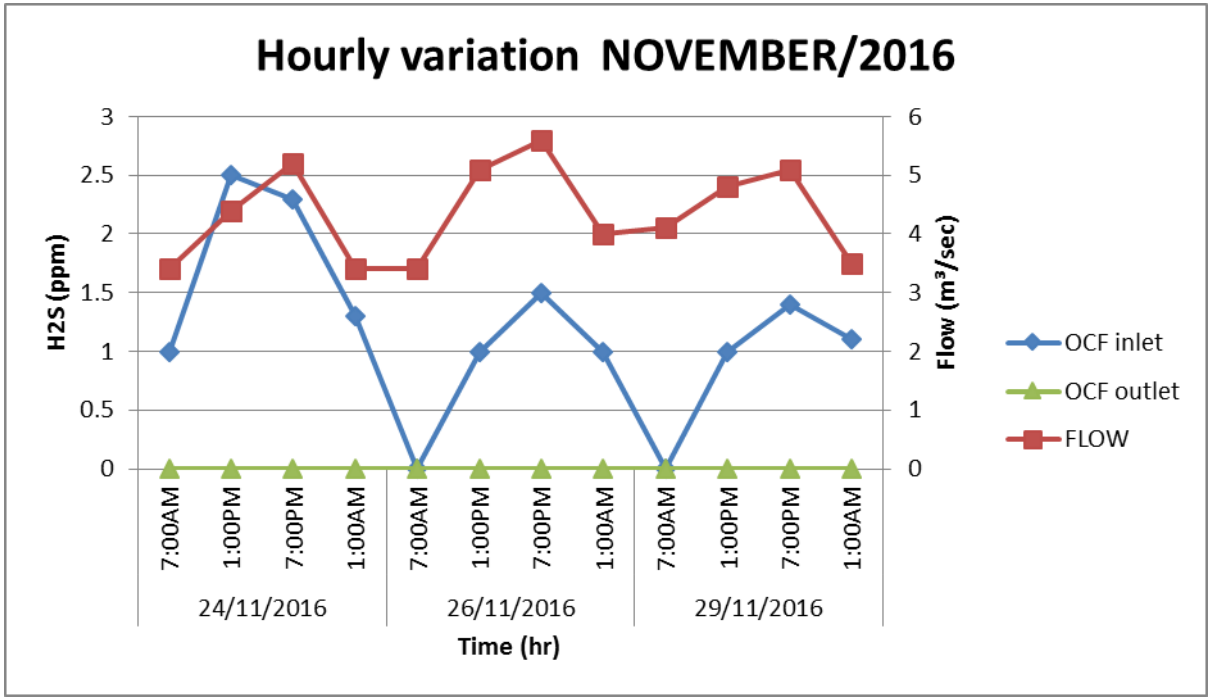
Daily Variations in H2S With Sulfates



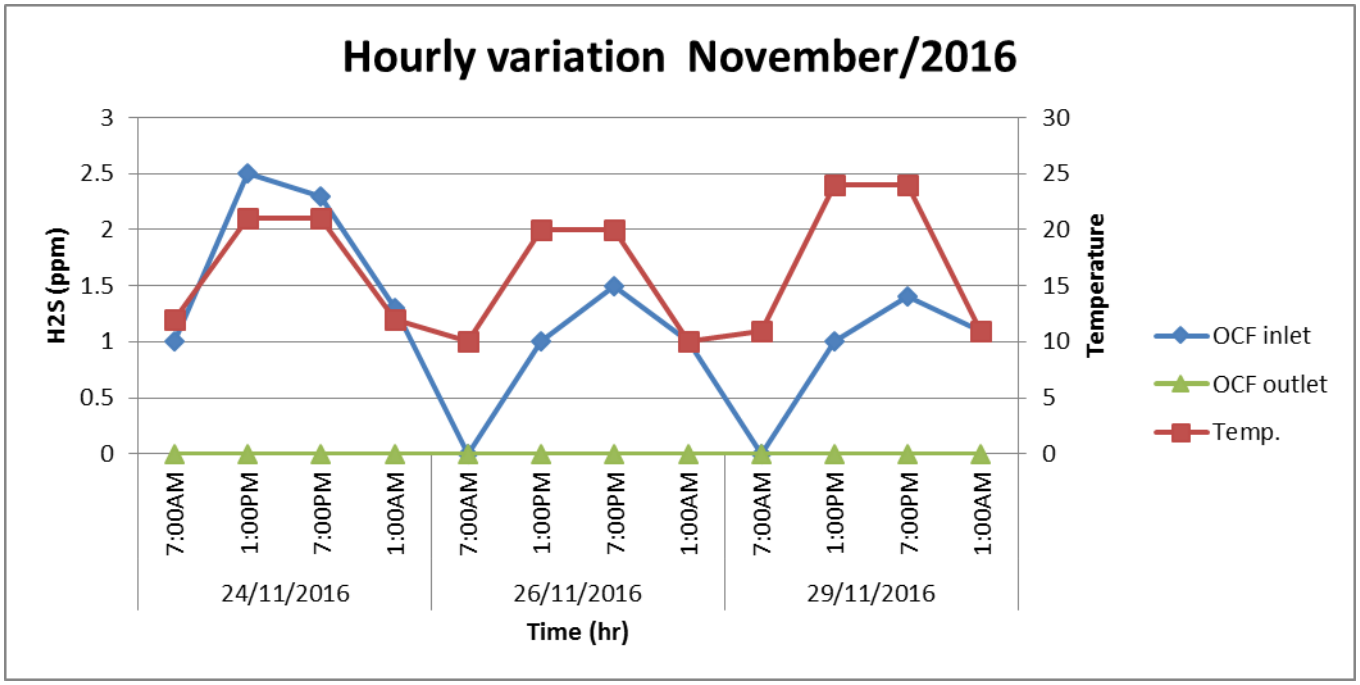
Hourly Variations in H2S with Flow Rate



Hourly Variations in H2S With Flow Rate



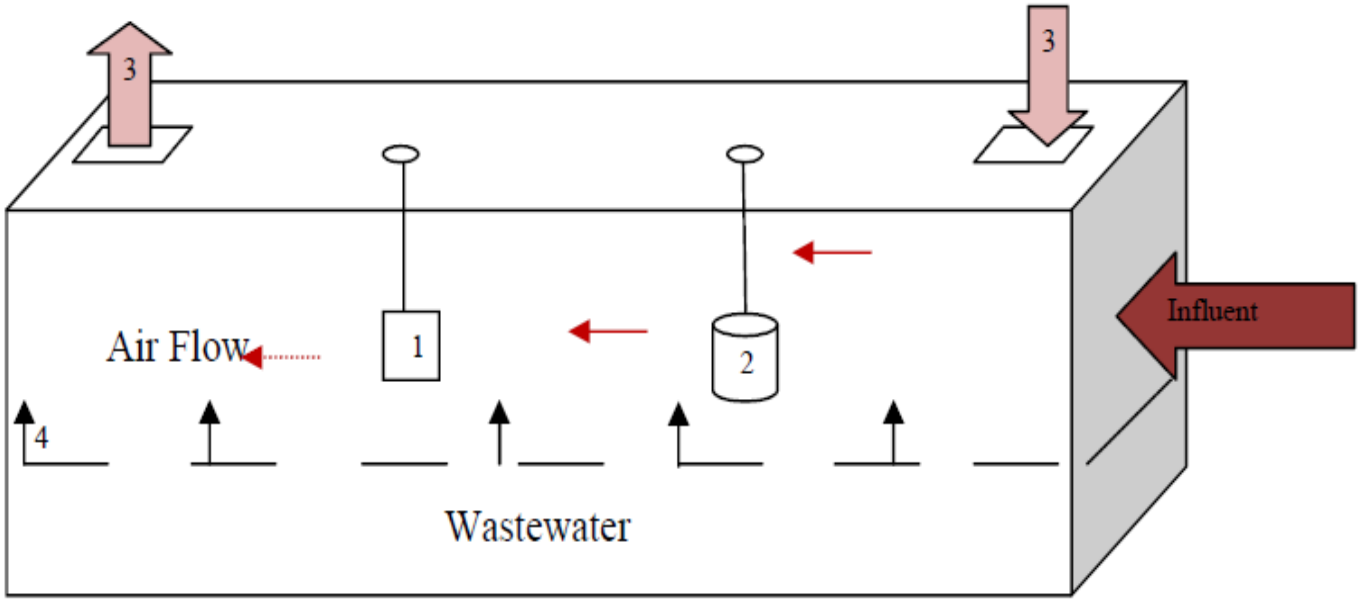
Hourly Variations in H2S With Temperature



H2S Removal Efficiency

Date, 2016	H2S at Inlet, ppm	H2S at Outlet, ppm	H2S Removal, %
March 21st	3.6	0.03	99.1
March 23rd	2.8	0.02	99.3
March 28th	3.8	0.02	99.5
March 30th	5.2	0.01	99.8
April 4th	2.5	0.01	99.6

H2S Emission Model



Legend: 1) Anemometer, 2) OdorLogger, 3) Air flow in/out of headworks chamber, 4) Air emissions from wastewater source.

Analysis of Data

- Devising an air monitoring plan for continuously recording H_2S emissions from the influent chamber of the headworks.
- Developing a plan to document variations in the H_2S emissions over a relatively long period of time rather than estimating based on short term monitoring of few grab samples.
- Identifying wastewater parameters which have potential to influence H_2S emissions and establishing a wastewater monitoring plan.
- Arranging the data into useable format for calculating H_2S emission factors.
- Performing statistical analysis to develop a H_2S model for individual WWTPs headworks and recommend roadmap for establishing a universal model.

Emission Rates of H2S

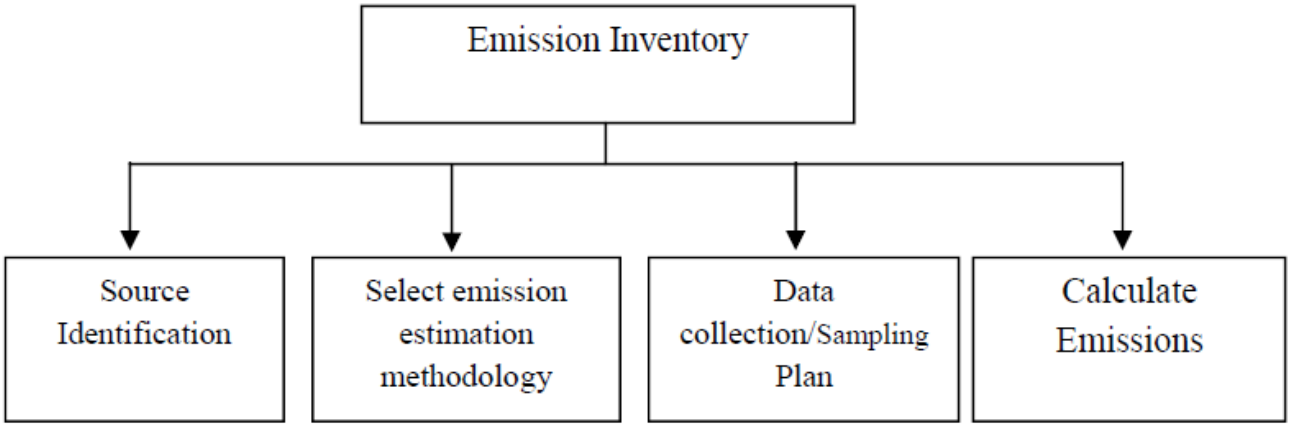
Independent Variables for the Model: Flow rate; Population; Area Served; WW Temperature (or Ambient Temperature); DO; BOD; Total Sulfides, pH and Hydraulic Retention Time

Dependent Variable for the Model: Emission Rate of H_2S

Emission Factor (EF) for H2S

This section formulates a methodology to calculate emission factors for H_2S. The Ontario Ministry of Environment's "Step by Step Guideline for Emission Calculation, Record Keeping and Reporting for Airborne Contaminant Discharge" published December 2007 (hereby referred to as Emission Guide) has been used as a guidance document to formulate methodology for this research. Figure 4.2 below shows the major steps involved to generate the Emission Inventory for a facility.

Figure 4.2: Flow Chart Showing Guidelines for Calculating Air Emissions



Parameter Estimation

The Parameter Estimate tables were next developed using only the independent variables selected based on results obtained from Pearson's Coefficient Matrix. The software eventually generated the modeling equation and the associated R-Square value.

Results of Parameter Estimation

Statistical dependency of H_2S emissions on wastewater variables

Row	Variables	EF-Flow	Flow	Temperature	BOD	pH	Total Sulfides
1	EF-Flow	1	-0.69	0.87	0.64	0.07	0.62
			0.0005	<.0001	0.0015	0.7381	0.0022
2	Flow	-0.69	1	-0.53	-0.58	0.009	-0.50
		0.0005		0.0129	0.0058	0.9669	0.0209
3	Temperature	0.87	-0.53	1	0.50	-0.03	0.55
		<.0001	0.0129		0.0192	0.8901	0.0087
4	BOD	0.64	-0.58	0.50	1	0.17	0.28
		0.0015	0.0058	0.0192		0.4511	0.2055
5	pH	0.077	0.009	-0.03	0.17	1	-0.18
		0.7381	0.9669	0.8901	0.4511		0.4268
6	Total Sulfides	0.62	-0.50	0.55	0.28	-0.18	1
		0.0022	0.0209	0.0087	0.2055	0.4268	

Dependence of H2S Emission Factor

According to raw data, Flow (-0.69) was most indirectly proportional and Temperature (0.87) was most directly proportional to the independent parameter EF-Population. Table 5.8 below shows the Pearson's Coefficient Matrix for the Bridge City WWTP sampling location. The matrix shows that flow (0.0005), temperature (<0.0001), BOD (0.0015), and Total Sulfides (0.0022) all have p-values (marked in green) less than 0.05. However, according to the p-values (Row 2), Flow is highly inter-correlated with BOD (0.0058). Some degree of inter-correlation was found between Flow and Temperature and Flow and Total Sulfides (Row 2). However, the model was developed using flow and temperature as the raw data as these two independent variables were recorded more extensively (continuous averages) than the data available for Total Sulfide (weekly grab sample). Also, Flow and Temperature are more correlated to EF-Flow and have a higher impact (-0.69 and 0.87 respectively) on EF-Flow than any other variables. Therefore, modeling was performed using Flow and Temperature, as these variables are correlated to EF-Flow and are least inter-correlated.

5. Conclusion

- The odor control system removed up to 99.9 % of the H_2S, and eliminated the odor nuisance as the H_2S level decreased from 6 ppm down to almost 0.0005 ppm .
- Statistical analysis showed a high correlation s between the inlet H_2S concentration and both the inlet wastewater temperature and flow rate. Other variables such as BOD, pH and sulfide concentrations also affected, but to a lesser extent, the H_2S emission factors.

Thank You for your Attention

Any Questions ?